Proceedings of Mechanical Engineering Research Day 2016, pp. 23-24, March 2016

Influence of transient response on suspension damping

A. Md Saad[1,2*], M.A. Salim[1,2], M.H. Harun[1], M.R. Mansor[1,2], M.Z. Akop[1,2], M.T. Musthafah[1,2]

[1)] Faculty of Mechanical Engineering, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia
[2)] Green Technology Vehicles Research Group, Centre for Advanced Research on Energy, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia

*Corresponding e-mail: adzni@utem.edu.my

Keywords: transient response; suspension damping; ride quality

ABSTRACT – Suspension system is one the most important components that affects overall performance of a vehicle. Determination of proper suspension damping is crucial to improve ride quality. The purpose of this study is to investigate the effects of transient response on suspension damping. Numerical simulation is used by representing ideal physical of vehicle quarter car model into Bond Graph. By lowering suspension damping, it reduces magnitude of rapid acceleration of the vehicle when it hits a bump. But, it takes longer time for the response to die out. However, by increasing the suspension damping, it increases magnitude of rapid acceleration significantly.

1. INTRODUCTION

With the changing of customer demands on vehicle overall characteristics, the focus areas in designing a vehicle have changed over time. Customers not only require better performance in terms of powertrain, but also other aspects especially in comfort level. It is not only limited to have luxurious feel inside the cabin with high quality material used and perfect components fitting, but the ability of vehicle to absorb forces due to road load also attracts customer attention.

Because of that, suspension design has become more complex in order to meet customer demands. Suspension system not only affect vehicle performance in terms of ride and handling, but also in safety. More research works are focusing in this area to meet continuous improvement requirements in suspension characteristics. This can be improved not only by having good suspension geometry but also by applying appropriate values of suspension parameters. Moreover, this process needs to be carried out accurately including suspension damping because it directly contributes to overall suspension performance.

The objective of this study is to investigate the effects of suspension damping on ride quality. It can be improved by lowering the value of the suspension damping. However, if this value is lowered too much, the car will oscillate long after it encounters a transient input and makes the car difficult to control. At the same time, an increase in the value of suspension damping can produce larger increases in the peak vertical acceleration of the body due to transient inputs. This response will be transmitted to the body and passengers by the suspension.

2. RESEARCH METHODOLOGY

This study was conducted by using numerical simulation approach. Software used for analysis was 20sim by converting ideal physical model of quarter car to Bond Graph as shown in Figure 1. Table 1 represented model parameters that were used for this simulation.

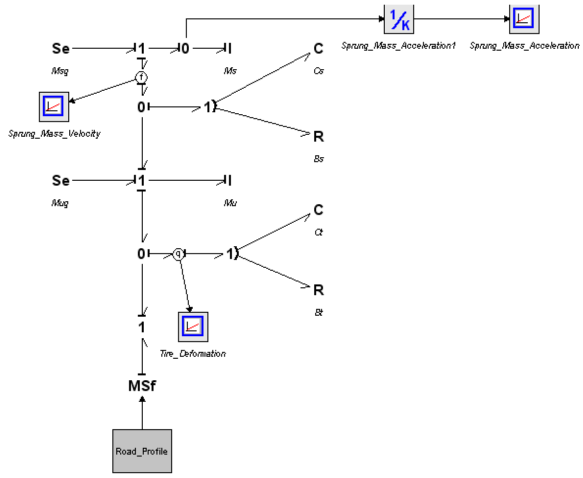

Figure 1 Bond Graph for quarter car model

Table 1 Model parameters.

Parameters	Values
Sprung Mass, M_s (kg)	1068
Suspension Stiffness, K_s (N/m)	74968
Suspension Damping, B_s (Ns/m)	2800
Unsprung Mass, M_u (kg)	146.4
Tire Stiffness, K_t (N/m)	775660
Tire Damping, B_t (Ns/m)	800

Analysis was carried out by assuming that a car was hitting a single bump. Transient input to the system was represented by an idealized single bump as shown in Figure 2. For a constant forward velocity of V_F, the velocity input for bump was given by Equation (1).

$$V_r(t) = \begin{cases} 0 \forall t < t_1 \\ \frac{RV_F}{L} \forall t_1 \le t \le t_2 \\ 0 \forall t > t_2 \end{cases} \quad (1)$$

Where L is wavelength and R is road roughness.

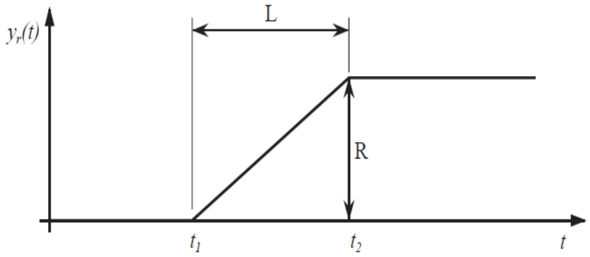

Figure 2 Single bump road model.

The time required to traverse the bump was given in Equation (2).

$$t_2 - t_1 = {}^{L}/_{V_F} \tag{2}$$

For the purpose of this study, constant forward velocity used was 25m/s, road roughness, R of 0.05m and wavelength, L of 0.5m. The car hit the bump at t_1 of 10s to allow transients due to gravity input to die out. Simulation final time was set at 15s. Three stages of simulation were carried out. The initial stage was by using original suspension damping value. Later, one lower and higher values of suspension damping were used respectively for comparison purposes.

3. RESULTS AND DISCUSSION

In this section, results of the test will be discussed in details. Sprung mass acceleration response of the system using original value of suspension damping of 2800Ns/m was shown in Figure 3. The first part of the response oscillation was due to the effect of sprung weight of the system. It took about 5 seconds before it died out and the vehicle hit a bump at t=10 seconds. When the vehicle hit a bump, the sprung mass acceleration increased rapidly and reached about 9m/s^2 before it died out after 4 seconds.

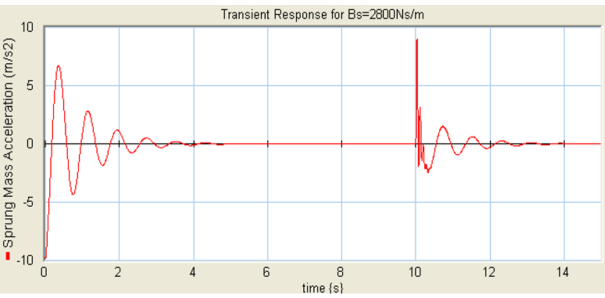

Figure 3 Sprung mass acceleration of B_s=2800Ns/m.

For the second stage of simulation, suspension damping was reduced to 1400Ns/m as shown in Figure 4. It displayed slightly different response compared to the original condition. The response took a longer time to die out because of the effect of gravity on the sprung mass. But once the vehicle hit the bump, magnitude of rapid acceleration of the vehicle was lower. It accelerated up to 7m/s^2 but the response took more than 5 seconds to die out. The longer response oscillation time improved ride quality but made the vehicle more difficult to control.

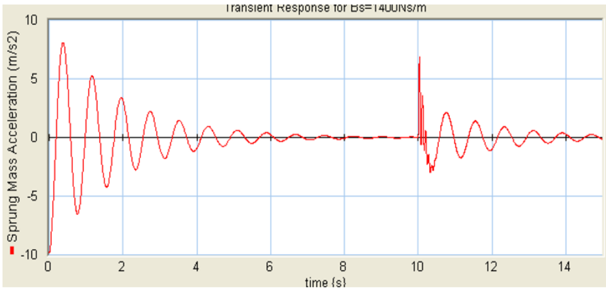

Figure 4 Sprung mass acceleration of B_s=1400Ns/m.

Suspension damping was increased to 5600Ns/m for the final stage of simulation. Time for the oscillation response to die out was shorter as shown in Figure 5. It took less than 3 seconds for the response due to sprung weight to completely vanish. Later, the plot showed no response when the vehicle hit the bump. In real condition, there was rapid acceleration response occurred with greater magnitude once the vehicle hit the bump. As the response died out almost instantaneously, the plot was unable to capture the acceleration response that transpired during that short period of time. By having higher suspension damping, it reduced the time for the response to die out but the system had to sustain higher magnitude of sprung mass acceleration.

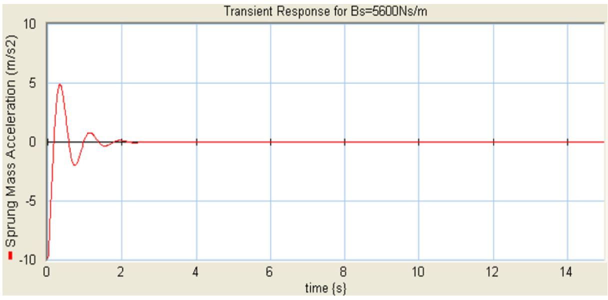

Figure 5 Sprung mass acceleration of B_s=5600Ns/m.

4. SUMMARY

This study was carried out to determine the effects of transient response on suspension damping. Software used for analysis was 20sim by converting ideal physical model of quarter car to Bond Graph. Results showed that by lowering suspension damping, it reduced magnitude of rapid acceleration of the vehicle when it hits a bump. But, it took longer time for the response to die out. However, by increasing the suspension damping, it increased magnitude of rapid acceleration significantly. But, the response died out almost instantaneously.

REFERENCES

[1] D.C. Karnopp, D.L. Margolis and R.C. Rosenberg, Sytems Dynamics; Modeling and Simulation of Mechatronic System, 4th Edition John Wiley & Sons Inc; 2005.

[2] T.D. Gillespie, Fundamental of Vehicle Dynamics, Society of Automotive Engineers;1999.